# Species Richness and Seasonal Abundance of Billbugs, *Sphenophorus* spp., from South Carolina Golf Courses[1]

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**ABSTRACT** Species richness and seasonal abundance of billbugs (Coleoptera: Curculionidae) were determined for four golf courses in South Carolina. In 2009 and 2010, 3970 adult billbugs representing six species were collected with unbaited pitfall traps. *Sphenophorus inaequalis* (Say) and *S. venatus vestitus* Chittenden represented 95% of the billbugs collected, whereas *S. coesifrons* Gyllenhal, *S. parvulus* Gyllenhal, *S. cariosus* (Olivier), and *S. minimus* Hart composed the remainder of the billbugs captured. Adult billbugs were collected from March to December, with a sex ratio of roughly 1:1. More individuals of *S. venatus vestitus* and *S. inaequalis* were collected from March to July and August to November, suggesting two overlapping generations annually. Given the extended activity period, at least two insecticide applications may be needed to reduce the abundance of larvae and adults.

**KEY WORDS** Turfgrass, phenology, species richness

Billbugs from the genus *Sphenophorus* (Coleoptera: Curculionidae) pose significant threats to turfgrass, pastures, and grain crops in the United States (Johnson-Cicalese et al. 1990). Seventy-one species of *Sphenophorus* have been reported from the United States and Mexico (Vaurie 1951). Of these, 24 species are present in South Carolina (Ciegler 2010) and at least eight species are common pests of turfgrass (Johnson-Cicalese et al. 1990). The bluegrass billbug, *Sphenophorus parvulus* Gyllenhal, and the hunting billbug, *Sphenophorus venatus vestitus* Chitteden, are the most commonly noted billbug pest species of cool- and warm-season turfgrasses in the United States, respectively (Tashiro 1987, Shetlar 1995).

Adult billbugs feed on the leaves and deposit eggs in the stems of turfgrass (Shetlar 1995). Neonates bore into and feed in the stem. Larger larvae bore into the crown and eventually feed on roots and stolons. The feeding activity of adults and larvae can damage and often kill the turfgrass. The dead grass desiccates and is devoid of roots when pulled up. Another sign of infestation is the fine dust-like frass left in the stem by the larvae.

Four issues complicate the management of billbugs. First, chemical management programs target both adults and larvae during periods of peak activities (Shetlar 1995). Therefore, a better understanding of their life history is critical to well-timed insecticide applications. However, the life history of billbugs in South

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Carolina is poorly known, limiting the ability of turfgrass producers and managers to achieve optimal control. Second, the significance of billbug damage is often overlooked because it is sometimes mistaken for damage by other pests or diseases (Shetlar 1995). Training and educational programs will be required to address this issue. Third, billbugs have the ability to use many turfgrass and grassy weed species for food, habitat, and refuge (Tashiro 1987). Billbug populations that persist and proliferate on unmanaged turfgrass and grassy weeds could become sources of infestation for sod farms, lawns, and golf courses. Lastly, multiple billbug species can be found on golf courses of the southern United States (Huang & Buss 2009, Doskocil & Brandenburg 2012), with variations among species in host preference (Huang & Buss 2009, Fry & Cloyd 2011, Reinert et al. 2011) and life history (Huang & Buss 2009, Doskocil & Brandenburg 2012). The biological and ecological differences among the species necessitate the development of species-specific management approaches.

The present study represents the first step in developing a billbug management program tailored for turfgrass systems in South Carolina by providing descriptive information on the species composition and seasonal abundance of billbugs in four golf courses located in different ecoregions of the state.

## Materials and Methods

Billbugs were sampled from February 2009 to December 2010 using a single unbaited pitfall trap at each of the four golf courses in South Carolina. The golf courses were located in different ecoregions, which differ in geology, soil, climate, and vegetation communities (Griffith et al. 2002). The golf courses were the Country Club of South Carolina (Florence, SC; Atlantic Southern Loam Plain), Camden Country Club (Camden, SC; Sand Hills), the Cliffs Center for Environmental Golf Research (Marietta, SC; Blue Ridge Mountains), and the Walker Golf Course (Clemson, SC; Southern Outer Piedmont).

The pitfall traps were installed in the roughs of the golf courses. The predominant turfgrass species in the roughs of the Country Club of South Carolina and the Walker Course was hybrid bermudagrass, *Cynodon dactylon* (L.) Pers. × *Cynodon transvaalensis* Burtt-Davy (cv. 'Tifway') (Poaceae). The predominant species in the roughs at Camden Country Club was common bermudagrass, *C. dactylon*, while at the Cliffs Center for Environmental Golf Research the predominate species was another bermudagrass, *C. dactylon* (cv. 'Celebration'). Turfgrass species and cultivars grown in the vicinity of the pitfall traps included common bermudagrass at the Country Club of South Carolina, zoysiagrass, *Zoysia* sp. (species and cultivar unknown) (Poaceae), and bahiagrass, *Paspalum notatum* Flügge (Poaceae) at Camden Country Club, and zoysiagrass, *Zoysia japonica* Steud. (cv. 'Meyer') at the Walker Course. Zoysiagrass, *Z. japonica* (cv. "Palisades'), *Z. matrella* (L.) Merr. (cv. 'Diamond'), and hybrid bermudagrass (cv. 'Champion', 'Miniverde', and 'Tifeagle'), were also found at the Cliffs Center for Environmental Golf Research. Grassy weeds, such as nutsedge, *Cyperus* spp., crabgrass, *Digitaria* spp., and goosegrass, *Eleusine indica* (L.) Gaertn., were also found at low abundance near the pitfall traps at all locations. Roughs at all sampling locations were maintained at a height between 2.5 and 3.8 cm and they received 49-98 kg nitrogen per hectare per year.

Each pitfall trap was installed by burying a large plastic pot (9.5 liter) in the ground with its rim level with the soil surface. Holes at the bottom of the plastic pots allowed rainwater to drain out of the traps. Four PVC troughs (1 m in length, 2.5 cm in diameter with a slit about 1.5 cm wide on the top) were laid horizontally and radiating in the four cardinal directions. The slit of the trough was level with the soil surface to allow surface-active arthropods to drop into the troughs. The outer ends of the troughs were sealed with PVC caps. The troughs funneled billbugs and other arthropods toward the plastic pot. Within the pot, a smaller plastic collection container (1.9 liter), with about 350 ml of ethylene glycol (as killing agent and preservative), was put directly under the opening of each of the four troughs to collect the captured arthropods. A plastic lid was placed over the top of the trap to shelter the collection container from rain and prevent other animals from reaching the preservative and captured specimens. The grass around the traps was mowed manually twice per month from April to November and once per month from December to March.

Contents of the pitfall traps were collected weekly, strained through a copper-wire strainer, rinsed thoroughly with tap water to remove excess ethylene glycol, and sorted to remove adult billbugs. Specimens were preserved in 70% ethanol before species and gender identification. Species identification was based on keys by Vaurie (1951), Johnson-Cicalese et al. (1990), and Ciegler (2010). Males could be easily distinguished from the females by the presence of a groove or depression on the metasternum and the first two abdominal sterna (Johnson-Cicalese et al. 1990). The abundance and sex ratio (proportion of females) of each species was recorded for each sampling date and location.

Abundance at each sampling location was plotted against the sampling dates to identify periods of greatest adult activity. Sex ratio was averaged across both years for each billbug species at each location. Chi-Square Goodness-of-Fit test was conducted to test whether the sex ratio of each species at each location deviated significantly from 50% females (PROC FREQ; SAS Institute 2011). The ability to compare the differences in abundance, species composition and sex ratio among the four locations was limited by a lack of replication or deployment of multiple traps at each location.

## Results and Discussion

Six billbug species, totaling 3,970 individuals, were collected in 2009 and 2010 (Table 1). More billbugs were collected at the Camden (35.9% of the total billbugs collected) and Florence (35.8%) locations than at the Clemson (16.5%) and Marietta (11.7%) locations. The hunting billbug, *S. venatus vestitus*, and the uneven billbug, *S. inaequalis* (Say), were the dominant species, accounting for 47.6% and 47.8% of the total billbugs collected, respectively. *Sphenophorus coesifrons* Gyllenhal was the third most numerous species (3.9%), followed by *S. cariosus* (Olivier) (nutgrass billbug), *S. minimus* Hart, and *S. parvulus* (bluegrass billbug).

*Sphenophorus venatus vestitus*, *S. inaequalis*, and *S. coesifrons* were collected at all four locations. At the Clemson, Florence, and Marietta locations, the order of abundance was *S. venatus vestitus*> *S. inaequalis*> *S. coesifrons* (Table 1). At the Camden location, however, the order of abundance was *S. inaequalis*> *S. coesifrons*> *S. venatus vestitus*. *Sphenophorus cariosus* was collected at the

**Table 1. Total abundance, species composition (percentage of total abundance) and sex ratio (percentage of females) of *Sphenophorus* spp. collected on four golf courses in South Carolina in 2009 and 2010.**

| *Sphenophorus* species | Sampling locations | | | | All locations combined |
|---|---|---|---|---|---|
| | Florence | Camden | Clemson | Marietta | |
| **Total abundance (all species)** | 1,423 | 1,426 | 655 | 466 | 3,970 |
| **% total abundance** | | | | | |
| *S. cariosus* | 0.3 | 0 | 2.6 | 0.2 | 0.5 |
| *S. coesifrons* | 0.3 | 23.4 | 1.5 | 0.9 | 3.9 |
| *S. inaequalis* | 33.8 | 63.7 | 20.5 | 2.3 | 47.8 |
| *S. minimus* | 0.1 | 0 | 0 | 0 | 0.1 |
| *S. parvulus* | 0 | 0 | 0 | 0.4 | 0.1 |
| *S. venatus vestitus* | 65.5 | 12.9 | 75.4 | 96.2 | 47.6 |
| **% females**[a] | | | | | |
| *S. cariosus* | 100 | - | 46.1 | 100 | 61.1 |
| *S. coesifrons* | 66.7 | 35.1** | 45.2 | 75.0 | 40.8* |
| *S. inaequalis* | 44.4 | 50.4 | 36.3** | 59.1 | 43.1 |
| *S. minimus* | 50.0 | - | - | - | 50.0 |
| *S. parvulus* | - | - | - | 50.0 | 50.0 |
| *S. venatus vestitus* | 56.6 | 57.1 | 41.3* | 50.1 | 50.3 |

[a]Sex ratios were analyzed with Chi-Square Goodness-of-Fit test to detect significant deviation ($P = 0.05$) from 50% females (PROC FREQ; SAS 2011). Values that deviate significantly from 50% females are marked with * ($P < 0.05$) or ** ($P < 0.01$).

Clemson, Florence and Marietta locations, while *S. minimus* and *S. parvulus* were collected only at the Florence and Marietta locations.

It was reported that six billbug species were collected in golf courses in North Carolina (Doskocil & Brandenburg 2012) and South Carolina, 16 species were collected (during the sampling period and while the traps were cleaned) in golf courses in north central and southern Florida (Huang & Buss 2009), and four species were collected in turfgrass evaluation plots in New Jersey (Johnson-Cicalese et al. 1990). *Sphenophorus rectus* (Say) was unique to North Carolina; no species was unique to New Jersey and South Carolina when compared to the species composition in Florida.

The collections from Florida (Huang & Buss 2009) and North Carolina (Doskocil & Brandenburg 2012) were dominated by *S. venatus vestitus* (80.9% and 99.7%, respectively). In New Jersey, the turfgrass plots were dominated by *S. inaequalis* in one year, but all species had similar abundance in another year (Johnson-Cicalese et al. 1990). The large numbers of *S. inaequalis* collected in the Camden location in the present study resulted in co-dominance by *S. inaequalis* and *S. venatus vestitus* in South Carolina. Differences among locations in abundance and composition of billbug species had been observed in North

Carolina (Doskocil & Brandenburg 2012) and Florida (Huang & Buss 2009). For example, similar to the Camden location, one golf course in north central Florida was dominated by *S. inaequalis* (Huang & Buss 2009, 2013a), whereas two golf courses in North Carolina harbored only *S. venatus vestitus* (Doskocil & Brandenburg 2012).

The presence and abundance of billbugs in South Carolina are likely associated with grass or sedge host species. The generalist species, *S. venatus vestitus,* has a wide preference for various cultivars of bermudagrass (Huang & Buss 2013b), zoysiagrass (Reinert et al. 2011), seashore paspalum (Chong, unpublished data), and other turfgrass and grassy weeds (Tashiro 1987). Therefore this species had a cosmopolitan distribution in South Carolina, whereas *S. parvulus* was only found in the northern-most sampling site where bluegrass is grown. The higher abundances of *S. cariosus* at the Florence location and of *S. coesifrons* at the Camden location were likely associated with a higher density of nutsedge and bahiagrass at these two locations, respectively.

The sex ratios of billbugs collected from the four golf courses in this study varied between 35% and 100% females, but only four of these values were statistically different from a 1:1 sex ratio. There were significant male-biased sex ratios for *S. coesifrons* at Camden, *S. coesifrons* at all locations combined, *S. inaequalis* at Clemson, and *S. venatus vestitus* at Clemson (Table 1). The sex ratios of *S. cariosus* and *S. coesifrons* at Florence and Marietta appeared female-biased, but these results were not statistically significant, probably due to the low abundance of these two species (Table 1). Huang & Buss (2009) reported sex ratios of 1.1:1.0 and 1.9:1.0 (males:females) for *S. venatus vestitus* and *S. inaequalis*, respectively. The sex ratios reported by Johnson-Cicalese et al. (1990) were male-biased with 1.8:1.0 for *S. venatus vestitus* and 2:1 for *S. inaequalis*. In the present study, the sex ratios of S. *venatus vestitus*, *S. inaequalis*, and *S. coesifrons* fluctuated without a clear pattern in both sampling years (Figures 1-3).

*Sphenophorus venatus vestitus* and *S. inaequalis* were collected from March to December in 2009 and 2010. Two periods of greater adult activity of *S. venatus vestitus* and *S. inaequalis* were identified from March to July and August to November in 2009 and 2010 (Figures 1 & 2). These results suggested two overlapping generations of *S. venatus vestitus* and *S. inaequalis* in South Carolina. The activities of adult *S. coesifrons* at the Camden location were greatest from June to November in 2009 and from March to June and August to November in 2010 (Figure 3). Doskocil & Brandenburg (2012) identified two overlapping generations of hunting billbugs per year in North Carolina, with peak activity occurring from April to June and August to October. Johnson-Cicalese et al. (1990) also suggested that there were two generations for *S. inaequalis* (in spring and autumn) and a partial second generation for *S. venatus vestitus* in New Jersey. In contrast, Huang & Buss (2009, 2013a) reported that *S. inaequalis* is likely univoltine in north-central Florida, whereas the number of generations of *S. venatus vestitus* could not be determined. In all studies, the precise length and timing of peak of activities varied from year to year and location to location.

Doskocil & Brandenburg (2012) demonstrated that adult billbugs are capable of reducing turf quality. Consequently, a management program should target both larvae and adults (Shetlar 1995). The extended period of adult activity

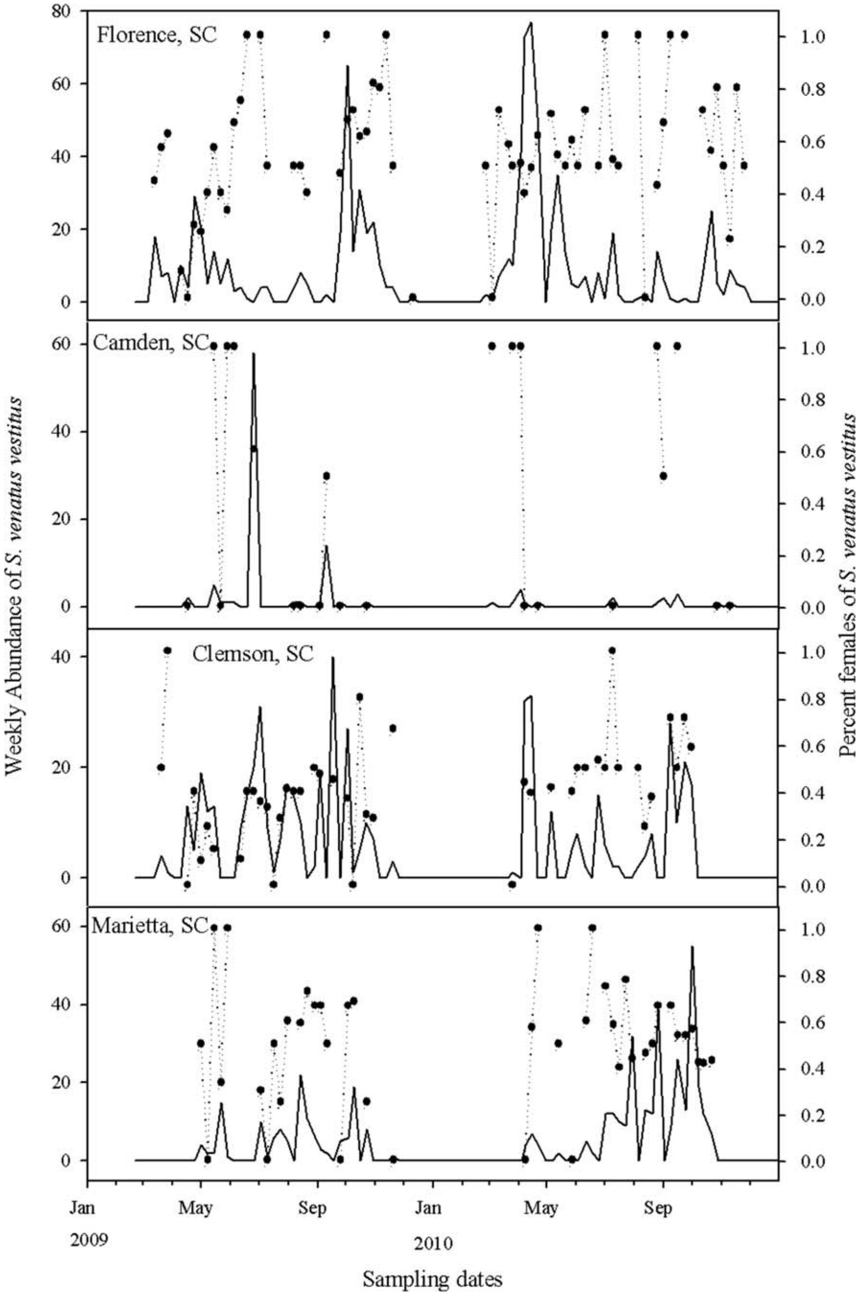


**Fig. 1.** Weekly abundance and sex ratio (% females) of *Sphenophorus venatus vestitus* collected on four golf courses in South Carolina in 2009 and 2010. The dotted lines representing the sex ratio were not continuous because no billbug was collected during certain sampling dates.

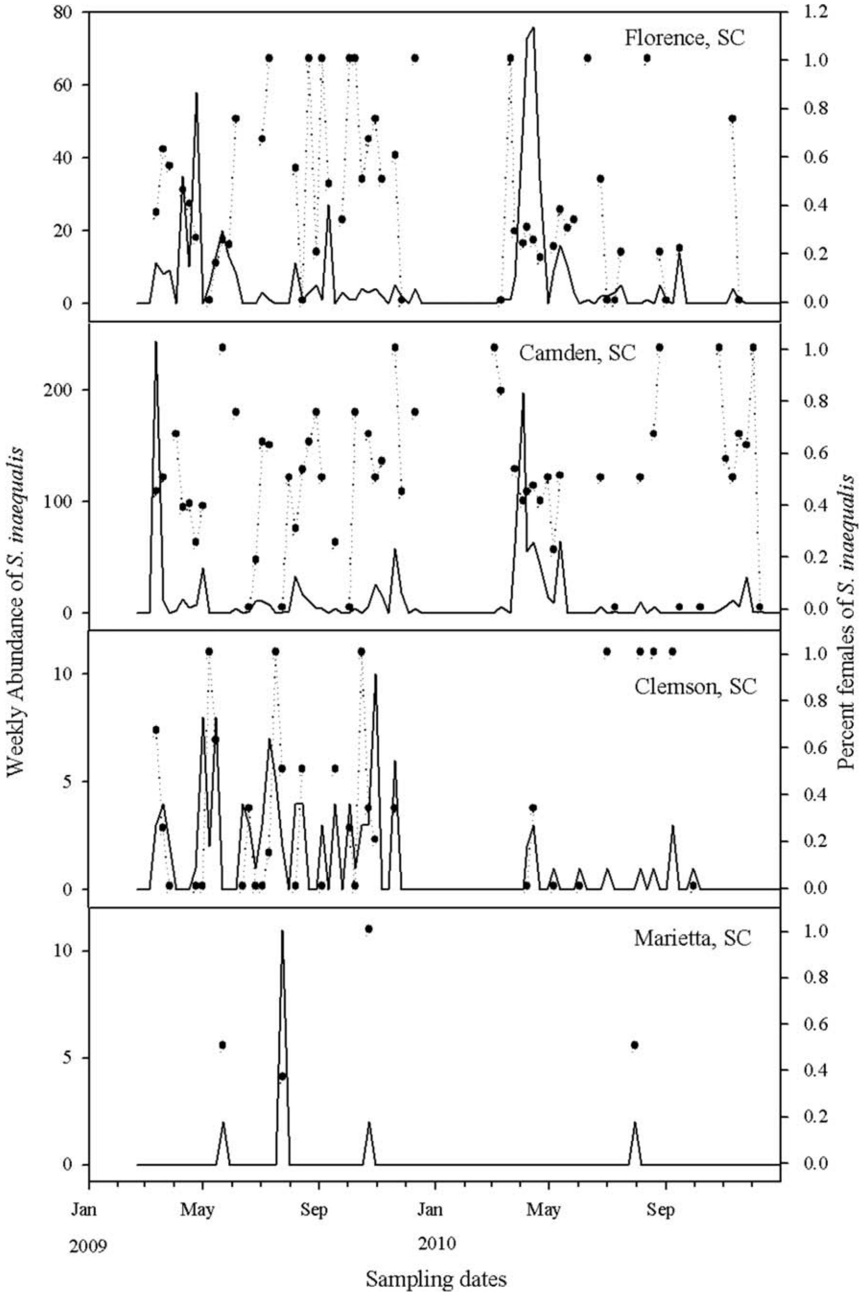


**Fig. 2.** Weekly abundance and sex ratio (% females) of *Sphenophorus inaequalis* collected on four golf courses in South Carolina in 2009 and 2010. The dotted lines representing the sex ratio were not continuous because no billbug was collected during certain sampling dates.

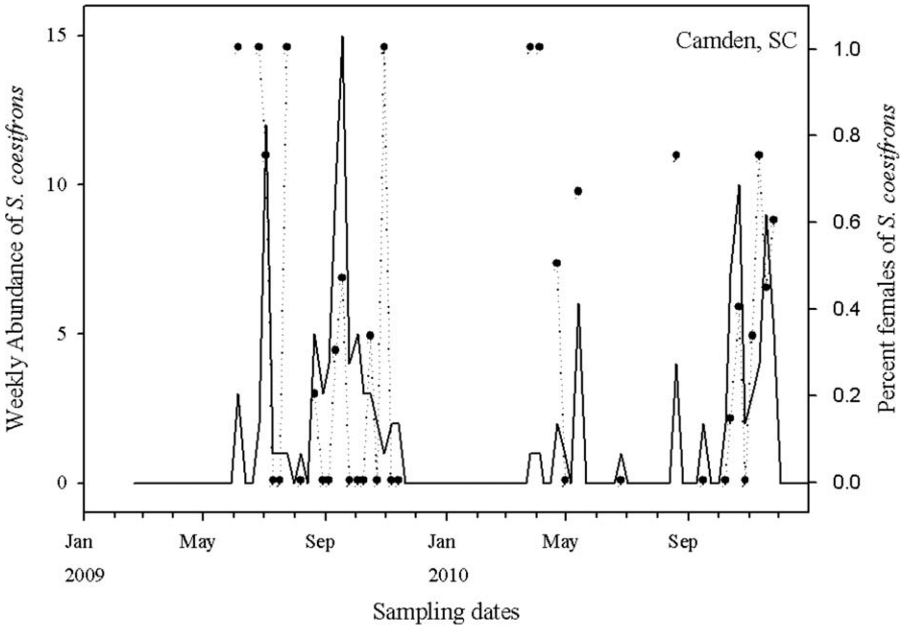


**Fig. 3.** Weekly abundance and sex ratio (% females) of *Sphenophorus coesifrons* collected on Camden Country Club (Camden, SC) in 2009 and 2010. The dotted lines representing the sex ratio were not continuous because no billbug was collected during certain sampling dates.

necessitates increased frequency and duration of insecticide applications to reduce the abundance of both life stages (Huang & Buss 2009, Doskocil et al. 2012). In South Carolina, turf managers should make insecticide applications in May and September to target adults during their peaks of activity in order to reduce labor and materials costs associated with the applications. Alternatively, products that contain systemic neonicotinoids (for larvae) and pyrethroids (for adults) should be used in well-timed applications to target both life stages (Doskocil et al. 2012).

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